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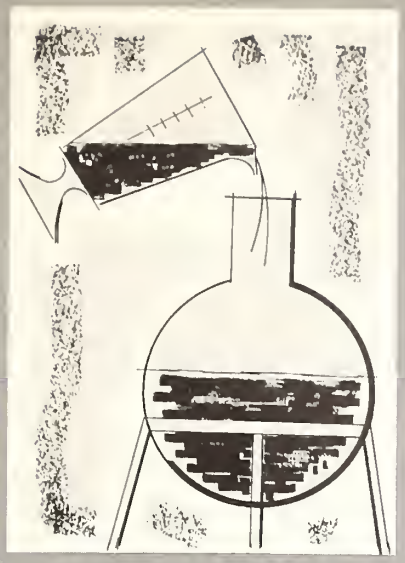

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MARKET POTENTIALS FOR MODIFIED EDIBLE FATS AND OILS

U.S. DEPARTMENT OF AGRICULTURE
ECONOMIC RESEARCH SERVICE
MARKETING ECONOMICS DIVISION

PREFACE

This study is part of a broad program designed to help increase sales and broaden the markets for farm products. The report contains information concerning the present status of various forms of modified edible fats and oils and economic and technical factors affecting their use in specific applications. It will provide guides to the fats and oils industry and to government laboratories for improving the utilization of fat and oil products.

The study was planned and developed by the Market Potentials Branch, Marketing Economics Division, Economic Research Service, in collaboration with the Oilseed Crops Laboratory, Southern Utilization Research and Development Division, Agricultural Research Service. The research was carried out under contract by IIT Research Institute (formerly Armour Research Foundation of Illinois Institute of Technology).

The study was conducted under the general supervision of Marshall E. Miller, Chief, Market Potentials Branch, and Philip B. Dwoskin, Leader, Food Uses Group, Market Potentials Branch. Fred Poats, Leader, Industrial Uses Group, acted as technical consultant in all phases of the research program.

T. H. Hopper, formerly chief, R. O. Feuge, and A. T. Gros of the Oilseed Crops Laboratory, Southern Utilization Research Development Division, provided many helpful suggestions throughout the study and in the preparation of this report.

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Washington, D. C. May 1964

HIGHLIGHTS

Product improvements through research and development could increase use of domestic modified edible fats and oils by 82 million pounds above normal growth over the next 5 years.

Of the 4 market areas studied, confectionery coatings and protective edible coatings offer the greatest potential for increase. About 16 million pounds of cocoa butter-like fats were used in confectionery coatings in 1962. Improvements in melting characteristics, gloss, and mold release are needed and could bring a 40-million-pound growth.

Protective edible coatings, a 35-million-pound-market in 1962, can be doubled if improvements in abrasion resistance, transparency, and reductions in cost are attained. The development of protective coatings for meat products including fish and shellfish could increase use of such coatings from a negligible quantity to 27 million pounds a year. Improved protective coatings for cheese, eggs, fruits, and food containers could increase their use by another 8 million pounds.

Edible food lubricants (17 million pounds were used in 1962) could be improved, thus increasing usage of modified edible fats and oils by 7 million pounds. Reduction of tendencies toward rancidity and polymerization are needed before such an increase can be achieved.

Little overall gain can be expected in use of food emulsifiers above the 13-million-pound normal growth expected in the next 5 years. In 1962, 61 million pounds (excluding shortening) were used.

MARKET POTENTIALS FOR MODIFIED EDIBLE FATS AND OILS

By O. C. Hester and Richard L. Boggs 1/

INTRODUCTION

During the last three decades, the United States has experienced relatively little change in the per capita consumption of food fats and oils. The annual usage level in 1930, for example, was 45.0 pounds per person and it rose only to 45.4 pounds per person by 1960 (26).

In spite of sizable shifts which have occurred within and between different product groups, the overall consumption of fats and oils has not been affected. This phenomenon is significant because it has placed a ceiling on the total market for fats and vegetable oils, which has been increased only as the population expanded.

Data on the utilization of fats and oils in edible and industrial uses are shown in table 1.

Markets for such products as butter and straight lard have been declining, while markets for fats in products such as frozen french fries and margarine have been expanding. Most of this rise and fall has been the result of interproduct competition, as between butter and margarine and between straight lard and shortening.

To increase overall consumption, rather than affect interproduct shifts, attention must be paid to new or different applications in which fat and oil products are not used. This is being done in the Department of Agriculture's development program to strengthen and expand markets for agricultural products. The Department already has had a leading role in developing and improving fat and oil products which are demanded by changes in food technology, consumer tastes, and regulatory requirements (5, 15, 17, 19).

Information is needed on the following: The specific types of modified fats and oils now utilized in specific end uses and the availability of such fats and oils; the relationships of competing fat and oil products; and the effect of modified derivatives upon the market for unmodified or natural fats and oils. This is an appraisal of present and potential edible fats and oils markets, and an identification of the areas in which research and development can be used most effectively to increase consumption of fats and oils.

Four applications--food emulsifiers, confectionery fats, protective coatings, and lubricants--were investigated in the following end-use markets: Bakery products; confectionery products; fruit, vegetable, and nut products; meat and meat products; cheese and egg products; prepared food mixes; and food container coatings.

The research included a comprehensive search of the literature on fats and oils of agricultural origin and their derivative products; interviews with research personnel, in both government and private industry, on new developments and research now underway; and a survey of suppliers and users.

1/ Hester is an agricultural economist with the Marketing Economics Division, Economic Research Service. Boggs was the project leader, Marketing Research, IIT Research Institute.

Table 1.--Domestic utilization of fats and oils, population, and gross national product

Year	Total fats and oils utilization 1/												Population 3/	Gross national product (in constant [1961] dollars) 4/
	Food uses										Industrial uses	Total		
	Butter	Margarine	Direct lard	Shortening	Mayonnaise and salad dressing	Frying oils: Potato chips	Frying oils: Frozen french fries	Mellorine	Other fats and oils 2/	Subtotal				
	Billion pounds												Million persons	Billion dollars
1946	1.22	0.47	1.64	1.47	0.26	0.11	--	--	0.49	5.66	3.65	9.31	141	328
1947	1.31	0.61	1.82	1.40	0.35	0.11	--	--	0.52	6.12	4.24	10.36	144	328
1948	1.20	0.74	1.86	1.40	0.38	0.12	--	--	0.60	6.30	4.07	10.37	147	341
1949	1.27	0.70	1.76	1.50	0.39	0.13	--	--	0.67	6.42	3.74	10.16	149	341
1950	1.33	0.76	1.91	1.71	0.40	0.15	--	--	0.76	7.02	4.27	11.29	152	369
1951	1.21	0.85	1.90	1.40	0.40	0.16	--	--	0.64	6.56	4.03	10.59	154	397
1952	1.10	1.05	1.83	1.61	0.43	0.17	0.01	--	0.77	6.97	3.74	10.71	156	411
1953	1.10	1.05	1.78	1.68	0.43	0.21	0.01	0.01	0.77	7.04	3.73	10.77	159	428
1954	1.19	1.11	1.63	1.97	0.42	0.23	0.01	0.01	0.85	7.42	3.64	11.06	162	421
1955	1.24	1.07	1.64	1.99	0.48	0.26	0.02	0.01	0.98	7.66	3.96	11.62	165	456
1956	1.22	1.11	1.63	1.85	0.51	0.30	0.02	0.01	0.98	7.63	4.09	11.72	168	466
1957	1.18	1.18	1.59	1.82	0.55	0.31	0.02	0.01	0.96	7.62	4.09	11.71	171	475
1958	1.18	1.27	1.64	2.01	0.58	0.32	0.02	0.02	0.91	7.95	4.14	12.09	174	467
1959	1.15	1.29	1.54	2.24	0.62	0.32	0.03	0.02	1.04	8.25	4.27	12.52	177	498
1960	1.11	1.37	1.36	2.30	0.63	0.34	0.04	0.02	1.07	8.24	4.35	12.59	180	514
1961	1.12	1.39	1.42	2.45	0.64	0.35	0.05	0.02	1.14	8.58	4.30	12.88	183	521
Average growth:	Percent													
	-1.6	6.5	-2.2	3.2	5.0	8.0			5.1	2.4	0.9	2.0	1.7	3.2

1/ Fats and Oils Situation (26) and IIT Res. Inst. estimates.
2/ Includes cooking oils, salad oils, and other miscellaneous commercial oils such as emulsifiers and lubricants.
3/ Statistical Abstract (34, p. 5).
4/ Statistical Abstract (34, p. 314).

Interviews completed in the course of the survey were among industries as follows:

Industry	Number of interviews
Baking	46
Confectionery	20
Meat	46
Fruits, vegetables, and nuts	46
Cheese and eggs	13
Prepared food mixes	7
Food containers	12
Suppliers	20
Other groups	27
Total	237

Geographically the firms were concentrated in the North Central and Atlantic States, corresponding to the patterns of population density and manufacturing activity (table 2).

The estimates herein reported are based on interviews and data published in the literature cited.

THE MARKET FOR FOOD EMULSIFIERS

An emulsifier, or "surface active agent" as it frequently is called, is used to permit water and oil to be mixed smoothly together, by suspending fine droplets of one within the other. The term "emulsion" has been extended in trade and industry to include most suspensions of solids in liquids. Food and industrial markets for products that use this phenomenon take over 450 million pounds of emulsifiers each year. Products that need emulsifiers range from bakery products to cosmetics and pharmaceuticals.

The results obtained from the oil and water mixture, or solid in liquid suspension, vary depending upon the particular end-product in which the emulsifier is used. In bakery products, for example, emulsifiers are used to control volume, uniformity, and fineness of grain, and to reduce the rate of staling or crumb hardening. In ice cream, on the other hand, emulsifiers are used to reduce the sizes of ice crystals and air bubbles. This diversity of benefits creates a market for many different emulsifiers, each with its own unique advantages and disadvantages. In some products, one emulsifier may be substituted for another, while in other products, one emulsifier may be clearly superior to the other.

Present Market

To define the present market for emulsifiers, two basic questions must be answered:

What are the competing emulsifiers which can substitute for each other and where are they used?

How much of each emulsifier is used in each end-product?

Table 2.--Number of interviews by type of firm and geographic location

Geographic area	Baking	Confectionery	Meat	Fruit, vegetables, and nuts	Cheese and eggs	Prepared food mixes	Food containers	Suppliers	Other groups	Total
	Number									
New England	1	3	4	1	--	--	--	--	2	11
Middle Atlantic	9	6	2	5	1	1	4	7	3	38
East North Central	21	10	22	26	9	2	6	6	11	113
West North Central	11	1	12	2	3	4	1	5	3	42
South Atlantic	2	--	2	4	--	--	--	1	6	15
East South Central	--	--	1	--	--	--	--	--	--	1
West South Central	1	--	--	--	--	--	--	1	--	2
Mountain	--	--	--	--	--	--	--	--	--	--
Pacific	1	--	3	8	--	--	1	--	2	15
Total	46	20	46	46	13	7	12	20	27	237

Five different types of competing or substituting food emulsifiers were identified in this study. The uses of each follow:

Monoglycerides.--Through the process of glycerolysis, wherein the triglycerides of natural fats and oils are reacted with an excess of glycerol in the presence of an alkaline catalyst, a "monoglyceride" product is formed. Unless the commercial product is molecularly distilled, it contains 60 percent or less monoglycerides, the remainder being mostly diglycerides with a small amount of triglycerides. 2/

Because the monoglyceride molecule has affinity to water as well as oil, it can be used to emulsify water and oil. These monoglycerides are excellent emulsifiers for food uses because they are edible and also are widely used in cosmetic and pharmaceutical preparations.

The amount of monoglyceride that may be used in bread is limited by the Food and Drug Administration (FDA). The total weight of monoglycerides and diglycerides cannot exceed 20 percent by weight of the emulsifier-plus-shortening combination. The total amount of monoglyceride, by itself, cannot exceed 8 percent of the combination, except that concentrated monoglycerides (that is, the proportion of the diglycerides has been reduced) may be used up to 10 percent of the combination. 3/ This FDA regulation implies a synergistic action from the diglycerides, but studies have shown that the diglycerides do not enhance the effectiveness of the monoglycerides (24). The usual quantity of monoglyceride when used in bread is 0.25 to 0.30 percent, the total weight of the bread.

In cakes and pastries, where FDA has not limited the amount of emulsifiers, monoglycerides are often used to increase the sugar ratio, a higher ratio yielding a more appetizing product. The usage level in cakes varies from 3 to 7 percent, depending upon the particular characteristics of the product and the baker involved. The usage level in pastries and sweets varies from 0.5 to 4 percent of the total weight of the end-product.

In cake mixes, monoglyceride emulsifiers play the same role that they do in bakery cakes. In addition, monoglycerides perform the function of aeration, that is, entrapping air so as to make a larger and lighter cake. When monoglycerides are used, their levels usually range from 1.0 to 1.5 percent based upon total weight of the mix.

In confectionery products, monoglycerides are used to promote a more intimate mixing of fat and water-soluble substances. They also can perform as many as eight other functions, which do not properly involve true emulsification. These are: (1) Retarding the hardening rate of starch-based confections, such as starch jellies and licorice, (2) retarding the loss of gloss and formation of undesirable surface greying, called "bloom," on confectionery coatings, (3) reducing stickiness of caramels and nougats, (4) reducing planning time, (5) improving the opacity of sugar coatings used

2/ During the process, fatty acid groups become detached from the triglycerides (the combination of three fatty acids and one glycerol) and react with the glycerol. Whenever a fatty acid leaves a glyceride, it is replaced by a hydroxyl group. A monoglyceride may be considered to consist of a glycerol skeleton to which are attached two hydroxyl groups and one fatty acid group. Consequently, a molecule has two water-loving (hydrophilic) hydroxyl groups and one oil-loving (lipophilic) fatty acid group.

3/ U.S. Food and Drug Administration. F.D.C. Regulations: Title 21, F.C.R. Part 17, Bakery Products, Section 17.1 (a) (1). May 1961.

on panned goods, (6) improving the palatability of mints, (7) impeding the migration of oil in peanut products, and (8) controlling crystallization in grained confections (24).

In starch-based confections, the monoglyceride usage level is around 0.1 percent. Usage levels up to 0.5 percent are common in mints, caramels, and nougats. In chewing gum, monoglycerides in concentrations of 0.5 to 1.0 percent are used to plasticize the chicle gum base, to reduce its tendency to stick to the teeth.

In frozen desserts, such as ice cream and mellorine, monoglycerides disperse the fats, thus imparting a resistance to churning out of fats during freezing, which in turn keeps ice crystals small and reduces the size of the bubbles of incorporated air. Such action leads to smoother body and less "grainy" texture of the product. Common monoglyceride usage levels are 0.10 to 0.15 percent in such frozen desserts.

In convenience and instant foods, particularly those with cereal or starchy bases such as macaroni, spaghetti, noodles, cooked cereals, and dehydrated potatoes, monoglycerides perform an important function--reducing pastiness. In starch-based foods, amylose starch molecules are liberated in the cooking, causing a sticky or gluey consistency. It has been shown that the monoglyceride forms chemical complexes with the freed amylose, and prevents it from forming a gelatinous mass (10).

Optimum monoglyceride usage levels are in the neighborhood of 1.0 percent for most of these starch-based products.

In shortening derived from either animal fats or vegetable oils, monoglycerides are one of the natural components. In breads and cakes, shortening is used as a tenderizer. It tenderizes by interposing films or clumps of fat throughout the mixture so that the protein and carbohydrate components do not cook to a hardened mass.

In many cake and pastry applications, an additional amount of monoglycerides will increase the permissible ratio of sugar to fat, which in turn yields a sweeter, lighter product. Since these monoglycerides are formed within the shortening, the amount of monoglyceride contained therein is not usually included in industry production data for monoglyceride emulsifier additives. Most household shortenings contain 2 percent of monoglycerides, while the high-ratio shortenings used in cakes and sweet doughs often contain up to 15 percent of monoglycerides.

Lactoglycerides.--The lactoglycerides, produced from monoglycerides, are mainly glycerol lactopalmitate (GLP) and glycerol lactostearate (GLS). They are formed through the replacement of one or two of the hydroxyl (OH) groups in a monoglyceride by lactic acid groups.

The primary utilization of lactoglycerides is in prepared cake and frosting mixes, where their abilities to emulsify and to aerate are superior to monoglycerides. They also are less likely to be affected by atmospheric moisture in stored dry products than the monoglycerides.

Lactoglycerides frequently are combined with monoglycerides for use in these prepared mixes, with the total emulsifier level usually not exceeding 2 percent of the weight of the total mix. The use of lactoglycerides as food additive has been approved by the Food and Drug Administration. 4/

4/ The National Archives of the United States: Federal Register, October 13, 1959, 8293.

Sorbitol esters.--Sorbitol, rather than glycerol, can be the polyol used as the base molecule to which fatty acids and other groups are attached. The predominate sorbitol esters are the sorbitan monoesters or triesters and polyoxyethylene sorbitan monoesters or triesters of stearic and oleic acid. 5/

These emulsifiers are used extensively for industrial applications, but their use in food has been restricted by FDA regulations. In cakes and cake mixes, the total amount of the sorbitol esters cannot exceed 0.66 percent of the total dry cake weight. The sorbitol esters are used in candy to impart opacity to sugar coatings (maximum FDA tolerance--0.2 percent) and to emulsify nonstandardized confectionery coatings (maximum FDA tolerance--1.0 percent). In frozen desserts, these esters may be no more than 0.10 percent of the finished product. 6/

These limitations on usage rates for the sorbitol esters frequently cause them to be used in combination with monoglyceride emulsifiers in a number of bakeries and confectionery products.

Lactic acid derivatives.--Derivatives of lactic acid, other than the lactoglycerides, have found increased usage recently in bread and cakes as emulsifiers or "dough conditioners" as they frequently are called (2). The two most common ingredients are calcium stearyl-2 lactylate (CSL) and stearyl-2 lactylic acid (SLA) (12), (13), (29). In general, their actions are thought to be derived from their ability to bond with the protein portion of flour and to retard the retrogradation of starch in yeast-leavened products.

The benefits attributed to these additives are similar to those generally credited to emulsifiers: Improved grain, texture, and loaf volume, prolonged keeping qualities, and better crust tenderness. The SLA is considered a surfactant or emulsifier, but the CSL lacks the hydrophilic tendencies of an emulsifier and is therefore called a dough conditioner. Since the CSL achieves results similar to those of emulsifiers, and is a substitute for them in bakery products, CSL is included in this market analysis.

There are indications that the SLA and CSL can achieve greater emulsification and superior product qualities at lower usage levels than other more common emulsifiers, including monoglycerides, lactoglycerides, and the sorbitol esters. When used together, multiple emulsifier compositions were found to demonstrate considerable synergistic functionality (13).

In standardized bakery products, such as bread, the FDA sanctions the use of SLA only up to a maximum level of 0.5 parts per 100 parts of flour. 7/

Lecithin.--Commercial lecithin is a mixture of phosphatides, which are mostly glycerol esters of fatty acids and phosphoric acid, the latter being, in addition, esterified with either of two nitrogenous bases. A fat or oil differs from lecithin in that it consists of a glycerol ester with three fatty acids in the molecule. Lecithin is obtained commercially from soybean and corn oils. Lecithin is often used in confectionery products. It disperses fats in the mixture, retards rancidity (oxidation), and prevents fat bloom on the products. In confections, the usage levels established for lecithin are:

5/ These esters are marketed under several trade names.

6/ The National Archives of the United States: Federal Register, 3441, April 11, 1962.

7/ The National Archives of the United States: Federal Register, 6079, July 7, 1961; and 4197, May 16, 1961.

Caramels, 0.05 to 0.12 percent; chocolate centers, 0.25 percent of the chocolate; chocolate coatings, 0.12 to 0.50 percent; fudge, 0.50 percent of the fat; cocoa butter, nougats, kisses, and taffies, 1.0 to 2 percent lecithin ratio to total fat.

The estimated 1962 consumption of food emulsifiers, exclusive of shortening uses, was 61 million pounds. Almost two-thirds of this was monoglycerides. Major uses were in bread, cake mixes, and candy (table 3).

Table 3.--Estimated amounts of five emulsifiers used in selected food products, 1962 1/

End-use product	Estimated emulsifier requirements	Mono-glycer-ides	Lacto-glycer-ides	Sorbitol esters	Lactic acid deriv-atives	Lecithin	Undis-tributed residual 2/
	Million pounds 1/						
Bread	40	30	--	--	4	--	6
Cake mixes	8	2	4	0.2	--	--	1.8
Candy	6	2	--	1	--	3	--
Gum	2	2	--	--	--	--	--
Frozen dessert	4	3	--	0.3	--	--	0.7
Convenience and instant foods	1	0.8	--	--	--	--	0.2
Total (excluding shortening)	61	39.8	4	1.5	4	3	8.7
Shortening	3/124	--	--	--	--	--	--

1/ Calculated on the basis of 45 percent-alpha monoglyceride.
2/ The undistributed residual reflects markets for which there was insufficient evidence to determine the emulsifier ingredient to which the market should be assigned. Market estimates for acetoglyceride emulsifiers, propylene glycol monostearate, and diacetyltartaric acid esters of the monoglycerides were not established. Without doubt, a large part of the residual belongs to them, particularly in the requirements for cake mixes.
3/ Monoglyceride is embodied with shortening, either naturally or intentionally. Only emulsifiers used as separate ingredients are included in these estimates.

All of the competing food emulsifiers are derived from agricultural products. With the exception of lecithin, all of them are modified fats, oils, or fatty acids. This interrelationship is important because it implies that gains in the market share by one emulsifier are made at the expense of another. To increase total fat and oil consumption in food emulsifiers the total market for products in which emulsifiers are used must be increased.

Competitive Factors

The three major factors which influence the selection of food ingredients are availability, cost, and technical efficiency. Since almost all the major components of food emulsifiers are produced from domestic agricultural commodities whose production is not subject to wide fluctuations, availability is not a problem.

At typical usage levels, the cost of emulsifier per pound of finished product is relatively small. The cost varies widely among the end-products (table 4). In cake mixes, for example, ingredients costing almost three times as much as the least expensive additive are being used. The most plausible explanation for this is that the technical considerations outweigh cost considerations.

Table 4.--Cost of emulsifiers per pound of end-product at typical usage levels, 1962

End-product	Monoglycerides	Lactoglycerides	Sorbitol esters	Lactic acid derivatives	Lecithin
	Cents				
Bread	.08	--	--	.20	--
Cake mix	.50	1	1.30	--	--
Candy	.12	--	--	--	.06
Gum	.12	--	--	--	--
Frozen dessert	.05	--	.09	--	--
Convenience foods	.18	--	--	--	--

The choice of one emulsifier over another depends almost entirely upon the unique technical peculiarities of each end-product. In most applications, there are no general rules for determining which emulsifier is best. The best emulsifier for yellow cakes, for example, may rank well down the list for white cakes or for chocolate cakes.

In practice, experience and intuition are the manufacturers guide in the initial selection of materials. Thereafter, trial and error is used in selecting combinations of ingredients to yield the best formulation, and a decision usually is made by the manufacturers' own taste panel, by a consumer-preference survey, or by one or more "experts."

An important question the edible fats and oils industry faces is: "Will increased lactic-acid-derivative emulsifier use decrease the overall consumption of shortening?" (13) 8/ Some sources indicate that improved emulsifiers reduce the amount of shortening needed up to 20 percent.

In this study, cross-sectional data on emulsifier and shortening usage were obtained from 18 bakeries. No statistical relationship was found between the overall rates of usage of emulsifier and shortening. Too few bakeries in the sample were using CSL and SLA to determine the effect of these emulsifiers on shortening usage. While expansions in the use of specific emulsifiers may reduce the amount of shortening used, the statistical evidence gathered in this study does not support the view that overall shortening usage is affected.

Market Potential

The growth of the total market for food emulsifiers is governed by the rate at which the demand increases for the emulsifier-using end-products. Disregarding (1) the introduction of any new products that use emulsifiers, such as the recent developments with "instant-type" dehydrated foods, (2) radical shifts in consumer

8/ U.S. Patent No. 2,978,329, Process of Prepared Yeast-Leavened Baked Goods.

preferences, or (3) the discovery of new ingredients which will increase greatly the per capita demand for existing products, overall food emulsifier usage will rise slowly with population increases and with higher standards of living. The demand for bakery goods, confectionery, and frozen desserts may be expected to grow at nominal rates of 2 to 4 percent per year, while convenience and instant-type foods may be expected to continue their present rapid growth for some time. On the basis of these growth assessments, the market potential for food emulsifiers is estimated at 74 million pounds for 1967 (table 5).

Table 5.--The market potential for food emulsifiers 1/

End-use	1962 emulsifier market	1967 emulsifier market	Market increase expected from normal growth
	Million pounds		
Bakery goods	40	48	8
Prepared mixes	8	10	2
Confectionery	8	9	1
Frozen desserts	4	5	1
Convenience and instant foods	1	2	1
Total	61	74	13

1/ Calculated on the basis of 45 percent-alpha monoglyceride and includes only emulsifiers added as separate ingredient (i.e., excludes shortening emulsifiers that occur naturally or are formed *in situ* by glycerolysis).

An increase of 13 million pounds in the emulsifier market is anticipated solely from normal growth in demand for the emulsifier-using end-products. It is not expected that additional growth for the fats and oils market will come from improved emulsifiers, since the total market size is limited by the demand for foods that use them.

Research and Development Needs

In this section, three questions are considered:

1. Toward what has past emulsifier research and development been directed?

2. What research and development would producing and consuming industries like to see undertaken in the future?

3. Can improved emulsifiers be used to increase the total consumption of fats and oils?

Research conducted on shortenings and on emulsifiers is interrelated, for both products work together to achieve a common purpose. Developments or improvements in one ingredient may be a byproduct of investigations on the other. Shortening improvements have tended to be basic in nature; for example, the development of hydrogenation techniques to reduce oxidative tendencies. Emulsifier research has been primarily product-oriented, whereby better emulsifier systems have been sought for specific uses. Examples of past research efforts are:

Interesterified lard.--The fatty acid radicals in the triglyceride molecules of lard have been redistributed to reduce graininess, to improve creaming quality, and to permit the incorporation of more air into cake batters. The resulting bakery products have had better texture and loaf volume characteristics (9, 28).

Improved superglycerinated shortening.--New methods have been found to incorporate concentrations of monoglyceride, greater than 10 percent in shortening, while avoiding previous tendencies of such high ratio shortening to become highly viscous and unmanageable. 9/

Plastic shortenings.--Improved shortenings have been developed by combinations of animal fats and vegetable oils. Formerly, lard was too soft and tallow too hard for many shortening applications. Liquid vegetable oils, which were hydrogenated to reduce rancidity, could be hydrogenated to a different degree to overcome an undesirably narrow plasticity range. 10/

Fluid shortenings.--These liquid shortenings are advantageous because they permit easier measurement by meters, are easier to handle, and provide a better dispersion of fat particles (22). 11/

Powdered emulsifiers.--For many applications, particularly in prepared mixes, powdered emulsifiers provide superior mixing with other dry ingredients and are more adaptable to mechanized handling systems. 12/

Sugar esters.--The sucrose esters of fatty acids have potential applications as food emulsifiers, and are reported to be superior to monoglycerides as an antistaling agent in bread. They have an anticipated low price of 15 cents per pound, but inability to remove undesirable compounds of dimethylformamide and fatty acids still restricts their use in foods (1, 3, 5, 33).

The Present Situation

While this is by no means an exhaustive list of shortenings and of developments in emulsifiers, it does indicate the general areas in which recent advances have occurred. Little publicity has been given to these research developments with emulsifers, or encouragement to consume the improved products resulting from new qualities they impart. In effect, there has been little, if any, stimulation of consumpton of breads, cakes, prepared mixes, candies, and other products which can be attributed directly to emulsifiers.

The need for improved emulsifiers has not been explicitly determined by the industry, but several general areas of improvement were indicated during the survey:

1. Need for improved antioxidants.

9/ U.S. Patents No. 2,963,371, Emulsifying Agents in Shortening and the Process of Producing Same; and No. 2,966,410, Shortening Emulsifiers and Method of Using Same.

10/ U.S. Patent No. 2,966,411, Plastic Shortenings and Manufacture Thereof.

11/ U.S. Patents No. 2,968,563, Liquid Shortening, No. 2,999,755, Fluid Shortening and Method of Making Same, and No. 3,004,853, Shortening Composition and Emulsifier System Thereof.

12/ U.S. Patents No. 2,913,342, Powdered Fat Composition and Process, and No. 2,978,329, Process of Preparing Yeast-Leavened Baked Goods.

2. A means of solidification of unsaturated fats without hydrogenation or significant changes in the degree of unsaturation.

3. More uniform lard quality for continuous bread-making.

4. Standardization of the requirements and regulations for emulsifiers.

5. Increased knowledge regarding the changes in emulsifiers and in emulsifier effectiveness during cooking.

6. Increased knowledge regarding rancidity development, to determine if hydrolysis, as well as oxidation, is involved.

None of these suggestions is designed to increase the total size of the emulsifier market. It may be said that, indirectly, improved bread, cake, and candy quality could possibly lead to increased demands for emulsifiers. Undoubtedly better emulsifier systems will improve the quality of the end-product. But the immediate result from improved emulsifiers might be to reallocate the shares of existing markets for different fats and oils, and emulsifiers derived from them. The short-term effect would not be an increase in the size of the total market for fats and oils or the consumer products that use them.

THE MARKET FOR CONFECTIONERY FATS

A second application of fats and oils, worthy of further research and development, is in confectionery coatings. Cocoa butter fats are the basis of true chocolate coatings. Some modified vegetable oils have been used to replace cocoa butter in chocolate-like confectionery coatings. "Confectionery fats," "hard butters," or "cocoa butter-like fats" as they are called, are used in coatings for candy. Bakery products such as crackers, wafers, and cookies are layered or coated with a variety of confections containing fats.

The development of cocoa butter-like fats has been stimulated by several factors:

1. During warm weather, the low melting point of cocoa butter presents a storage and transportation problem.

2. True chocolate coatings frequently develop an undesirable grey color on the surface called "bloom."

3. Cocoa butter fats are difficult to temper to different melting points or consistencies.

4. The cocoa bean, from which cocoa butter is obtained, is an imported commodity. Unstable world conditions cause difficulties in obtaining the desired supplies and make prices of the bean fluctuate widely.

Present Market

Cocoa beans, the source of cocoa butter, are imported from African, South American, and the Caribbean countries. In the United States, which consumes almost one-half of the world's crop, the beans are cleaned, roasted, dehusked, and broken into small particles called nibs. The nibs then are blended to achieve the desired color, flavor, and aroma, and are ground.

Friction from the grinding process generates heat that melts the nibs into a pasty substance called "chocolate liquor." From the liquor, the chocolate manufacturer extracts cocoa butter and makes cocoa powder from the press cake, each of which is about 50 percent by weight of the liquor. Or he may process the liquor to obtain baking chocolate, sweet chocolate, or sweet milk chocolate. The sweet or sweet-mild chocolate materials thus prepared may be used as a coating for candies, fondants (covered centers), and bars; or it may be molded into solid chocolate bits or candies. Chocolate and chocolate-type coatings are used in other industries--as coatings for ice cream bars and as coatings for marshmallows, biscuits, and crackers (30).

Substitutes for the chocolate liquor or "added" cocoa butter in confectionery coatings may be made from processed vegetable oils, which duplicate many of the cocoa-butter characteristics (25) (20) (19) (15) (27). These confectioners' fats are of two different types, depending upon the vegetable oil used. One such fat, which is high in lauric acid content, is manufactured from coconut oil or palm-kernel oil, both of which are imported. The other, nonlauric acid type fat, may be manufactured from either cottonseed oil or soybean oil but has not been developed commercially. Each type is described more fully in the following paragraphs.

Cocoa butter fat.--Cocoa butter is a fat having unusual physical properties. It melts sharply and completely at a temperature of 92° to 94° F.--just slightly below body temperature. It is a hard brittle solid, (i.e., it possesses "snap") at normal room temperatures. When eaten, it melts completely in the mouth and produces a pleasing smooth liquid and cooling sensation.

Cocoa butter is used in confectionery products because its physical properties contribute glossy coatings, absence of stickiness, and favorable volume shrinkage effects in molding operations. The unique melting property of cocoa butter results from the types and proportions of component fatty acids and their arrangement in the glyceride molecule (14).

Cocoa butter coatings also have certain disadvantages. The formulation of a greyish-white film on the surface of solid or chocolate-coated products has plagued the industry for years. This film is called "bloom" and is caused by fat and sugar crystals migrating to the surface of the chocolate. In addition, at summer temperatures above the mid-80's, some chocolate bars begin to soften and lose their shape, and melt when the temperatures reach the low 90's. Because of this physical instability, confectioners must curtail output of chocolate products during the summer months. Summer heat affects shelf-stock items, and minimum inventory adversely affects sales volumes.

In commercial practice, the amount of cocoa butter used varies with the nature of the chocolate product. Unsweetened or bakers' chocolate, for example, is made directly from chocolate liquor and contains about 50 to 55 percent cocoa butter, while cocoa powder usually contains from 10 to 20 percent fat. Sweet chocolate commonly contains about 42 percent liquor, which is one-half fat, and an additional 16 percent added fat, for a total fat level of about 37 percent. Sweet milk chocolate contains less fat, by virtue of its dilution with milk solids, and has a total fat level of about 30 percent. The percentages given are all based upon the total weight of the finished product. (FDA standards for these products are given in FDA Regulations, Title 21, C.F.R. Part 14, "Chocolate and Cocoa Products", Sections 14.2-14.6.)

Lauric fats.--The lauric acid-type fats are prepared from imported coconut oil, palm kernel oil, and other tropical oils. These fats are used in conjunction with, or in place of, cocoa butter in confectionery coatings. When lauric fats, which are

frequently called "cocoa-butter substitutes" or "hard butters," are added to cocoa butter coatings, the melting point can be raised to accommodate summertime temperatures. Lauric fats also may be used in place of both cocoa butter and chocolate liquor in summer-use product coatings.

The principal technical advantages of the lauric fats over straight cocoa fats are their higher melting points and their ability to reduce the formation of bloom. Their disadvantages, however, are such that they limit their use. For example while lauric fats raise the melting point of cocoa butter coatings, the range of temperatures over which the fat softens and melts is widened. This undesirable effect upon cocoa butter is called an " incompatibility" on the part of the lauric fats.

As an alternative to using chocolate liquor with lauric fats, cocoa powder can be used to provide the chocolate flavor. Cocoa powder contains 20 percent cocoa butter, as opposed to 50 percent in the liquor, and lesser degrees of incompatibility are experienced. In practice, however, sufficient quantities of cocoa powder cannot be added to impart the desired flavor. Also the lauric-acid fats have a tendency to undergo hydrolysis in the presence of moisture, generating an undesirable soapy flavor by the hydrolysis of the lauric fats within the coating.

Commonly used formulas for lauric acid-type coatings call for 33 percent of lauric fat and from 12 to 24 percent of cocoa powder, based upon total coating weight, and depending upon the exact flavoring and color desired. 13/

Nonlauric fats.--The nonlauric acid-type fats are prepared from domestic cottonseed and soybean oils. Their principal advantage over the lauric fats is that they are more compatible with chocolate liquor, without a significant loss in chocolate flavor. The nonlauric type products in coatings do not foster bloom, do not soften and melt at summertime temperatures, and do not develop the undesirable soapy flavor. The nonlauric fats do, however, have a tendency toward oxidative rancidity.

In chocolate-like coatings, the nonlauric fat exactly displaces the "added" cocoa butter. A typical chocolate coating containing, for example, 17 percent of chocolate liquor and 25 percent of cocoa butter would be equivalent to a similar coating containing 17 percent of chocolate liquor and 26 percent of the nonlauric fat. These percentages are based upon the total weight of the finished coating. 14/

The estimated 1962 market for confectionery fats used in coatings and solid chocolates was 209 million pounds 15/ (table 6). The estimates for total fat requirements refer to the cocoa butter or substitute contained in chocolate liquor and also the fat added to the liquor to produce each coating. The estimates for "added" fat requirements refer to the fat not originally contained in the liquor, while the figures for cocoa butter and butter-like fat market shares indicate the breakdown of the "added" fat requirements.

These estimates show that the cocoa butter-like fats have captured only a very small portion of the total confectionery fat market.

13/ U.S. Patents No. 2,928,475, . . .Confectioners' Hard Butter, and No. 3,012,891, Cocoa-Butter Substitute.

14/ U.S. Patents No. 2,924,528, Synthetic Hard Butter; No. 2,972,541, Domestic Oil Hard Butters. . .; and No. 3,012,890, Synthetic Cocoa Butter Substitute.

15/ This study was limited to markets for confectionery coatings; similar coatings on ice cream bars, crackers, and wafers were excluded.

Table 6.--The market for confectionery fats

End-product	1962 coating requirement	1962 total fat requirement	1962 "Added fat" requirement	Market share	
				Cocoa butter fat	Cocoa butter-like fat
	Million pounds				
Coated bar goods 1/	180	63	35	21	14
Coated bulk and packaged goods 2/	170	56	8	6	2
Solid chocolates	300	90	12	12	0
Total	650	209	55	39	16

1/ Includes solid and coated candy bars.
2/ Includes fondants and chocolate cream centers, sold primarily by the pound, as well as specialties such as coated raisins, peanuts, and coated candies sold primarily by the package.

Source: U.S. Department of Commerce (34); and estimates by IIT Research Institute.

With the present state of development, the lauric fats, which are not used in conjunction with chocolate liquor, compete for the entire fat requirement market of 209 million pounds. The nonlauric fats, since they are added to chocolate liquor, compete for only the 55-million-pound market for "added" fats. An improved nonlauric fat would also compete for the market held by lauric fats.

Competitive Factors

The candy manufacturer considers three factors in selecting ingredients: Availability, cost, and technical efficiency. The supply of cocoa beans and cocoa butter is often in question. Temporary shortages have caused the price of cocoa butter to fluctuate widely from year to year (table 7).

The price fluctuation from $0.52 to $1.03 per pound in a 4-year span has caused many confectioners to seek cocoa butter substitutes (table 7). Since cocoa butter is an important ingredient in most coatings, roughly one-third by weight in most instances, wide variances in its cost result in pricing headaches for the candy manufacturer. This is especially true since he is subject to extremely narrow product prices by his competition and marketing system and because candy volume marketed from year to year is in a narrow range.

The second criterion for the selection of ingredients is cost. The cost of lauric and nonlauric coating ingredients is from 5 to 12 cents per pound less than cocoa butter coatings (table 8). If cost were the only consideration, both types of cocoa butter substitutes would have a decided advantage for the confectionery manufacturer.

Technical considerations, however, check the widespread utilization of cocoa butter-like fats. At present, the deficiencies of lauric fats with respect to compatibility, flavor, and undesirable saponification, as well as the tendency of nonlauric

Table 7.--Cocoa butter prices per pound

Year	High	Low
	Dollars	
1952	0.79	0.61
1953	1.18	0.67
1954	1.28	0.85
1955	0.82	0.44
1956	0.69	0.44
1957	0.97	0.60
1958	1.03	0.87
1959	0.86	0.61
1960	0.64	0.56
1961	0.66	0.52

Source: "Hi-Lo Chemical Price Issue," (31).

Table 8.--Confectionery fat costs per pound, 1962

Ingredients	Cocoa butter 1/ coating	Lauric 2/ fat coating	Nonlauric 1/
	Dollars		
Fat	.15	.10	.10
Chocolate liquor	.08	--	.08
Cocoa powder	--	.02	--
Total fat-related	.23	.12	.18

1/ Typical composition containing 25.5 percent added fat and 17.0 percent chocolate liquor.

2/ Typical composition containing 33.0 percent added fat and 10.0 percent cocoa powder.

fats to become rancid, have been noted. In addition, both fats lack the glossy appearance desired by consumers, which is best obtained from true chocolate coatings.

Another hurdle to get over before wider utilization of cocoa butter substitutes is realized is the position of the Food and Drug Administration with respect to product labeling. A product cannot be called "chocolate" if it contains fats other than cocoa butter, except for the small amount of milk fats and emulsifiers permitted. If such fats are used, then the label should bear the name in the FDA standards. 16/

16/ U.S. Food and Drug Administration. F.D.C. Regulations. Title 21, C.F.R. Part 14, Chocolate and Cocoa Products (especially sections 14.2, 14.6, 14.11 and 14.12). May, 1962.

It should be noted that the lauric fats displace chocolate liquor but still utilize cocoa powder, while the nonlauric fats are used in place of "added" cocoa powder and cocoa butter. The development of a satisfactory imitation chocolate flavor is the key to expansion of the domestic fat market in confectionery uses.

Market Potential

The growth of the total market for confectionery fats is governed by the rate at which the demand increases for coatings. Based on the assumption that recent trends in the pattern of candy consumption will continue, the total market for confectionery fats is estimated at 289 million pounds in 1967 (table 9).

Table 9.--The market potential for confectionery fats

End-product	Total fat requirements		Cocoa butter-like share			
	1962	1967	1962	1967 1/	1967 2/	Net gain 3/
	Million pounds					
Coated bar goods	63	76	14	25	40	15
Coated bulk and package goods	56	75	2	5	30	25
Solid chocolates	90	138	0	0	0	0
Total	209	289	16	30	70	40

1/ Estimated on the basis of normal growth.
2/ Estimated on the basis of extraordinary growth.
3/ Estimated market gain for improved cocoa butter-like fats.

Estimates of the cocoa butter-like fats market for 1967 were made under two assumptions.

First, it was assumed that few technical gains would be made to overcome the several shortcomings of the cocoa butter substitutes and that incompatibility, improper gloss, and rancidity would continue to plague the industry. Normal growth in demand would come primarily from increased consumption of confectionery goods through population increases and from wider acceptance of the presently developed products. Even though hard butters, such as cocoa fat substitutes, have been known for many years, they have not been promoted and marketed on a large scale commercially until recently. Their widespread acceptance in use will take some time.

Second, it was assumed that the needed improvements would be substantially met, and that rapid growth would result in the 5-year period. Industry sources estimate that an improved cocoa butter-like fat would command more than 52 percent of the total fat requirements for coated bar goods and 40 percent of the total fat requirements for coated bulk and packaged goods. On the basis of projected consumption, this would amount to 40 million and 30 million pounds, respectively, in these two uses.

A modification in the regulations on labeling chocolate-like coatings and development of a satisfactory imitation chocolate flavor would open substantially larger markets to both lauric and nonlauric fats and raise the market potential to as much as one-half of the estimated 289-million-pound market for 1967.

Research and Development Needs

The goal of hard butter fat research in the past has been to produce a coating from fats that is as palatable as chocolate, that will withstand high temperature and humidity, and retain its gloss and consumer acceptance. At the present time, coatings from hard butter fats are available which duplicate the narrow plastic range of cocoa butter at a slightly higher temperature. A major problem, however, is obtaining proper gloss retention. Various emulsifiers, among them the sugar esters, have been used to enhance gloss, but they have adversely affected melting points and flavor.

A secondary problem is insufficient shrinkage for proper mold release. The incompatibility of lauric acid fats with chocolate liquor and cocoa powder restricts the complete duplication of authentic chocolate flavors. The oxidative tendency of present domestic nonlauric acid fats compared with cocoa butter still restricts their usefulness. These problems are well known to research groups seeking to produce acceptable chocolate-like coatings.

THE MARKET FOR EDIBLE PROTECTIVE COATINGS

Protective coatings are used on many food products to provide a barrier against the surrounding environment, to reduce the rate of dehydration, and to minimize stickiness. Most protective coatings are not edible--for example, the organic polymer films such as polyethylene and cellophane, which are often used to wrap meat, fruits, and vegetables. On some products, such as raisins and nuts, it is not practical to have a removable coating--an edible coating is necessary. This section is concerned with the market for edible protective coatings, the needs for which can be satisfied by recently developed film-forming fat-derivatives called "acetoglycerides" (4, 11, 18, 19).

Present Market

Seven commodity markets were examined for potential applications of the acetoglyceride protective films. The nature and requirements for protective-edible films in each of these seven markets follow:

Meat.--There are potential acetoglyceride markets on beef, veal, pork, chicken, turkey, fish, and shellfish. For each of these products, the frozen meat has sufficient rigidity to permit the application of a flexible unsupported film. Use of acetoglycerides on frozen consumer meats has been tested in at least one major city (21). Acetoglyceride films crack as nonrigid fresh meat bends and changes its shape and, therefore, are not satisfactory in this use.

Unfrozen beef frequently is aged for several days to improve its flavor characteristics. After the beef is slaughtered, a cotton chill cloth is drawn tightly around the warm carcass to reduce surface dehydration and to hold the carcass shape. Chill cloths and other coverings must hold in the moisture, while at the same time oxygen must be permitted to contact the meat in order to preserve its red color.

After chilling at 32° to 35°F., the chill cloth is removed, and the carcass is stored uncovered for 1 to 3 weeks in a cooler. For in-plant handling--and for shipping--paper, cellophane, or cheesecloth stockinettes are wrapped around the meat to protect it from dirt, oil drippings, and other contamination. This covering is not intended to reduce dehydration, but such incidental protection would be welcome also.

Veal, after it is slaughtered, is stored with its natural skin left in place, for veal lacks the natural fat layer protection of beef and pork and is especially susceptible to dehydration effects. The butcher or packer usually leaves the natural skin in place during aging. This ordinarily does not exceed 1 week.

Fresh pork has a thicker fat layer than either beef or veal and, therefore, is not as subject to severe dehydration. Pork is shipped in smaller pieces than beef--usually in loins, hams, and other cuts. The smoked crust and fat of the semiprocessed or processed ham serves as a protective layer. It frequently is reinforced with some form of nonedible polymer film or wrapping.

Processed meats, such as sausages and frankfurters, are wrapped in plastic film before they are offered for sale to consumers. These wraps help to reduce shrinkage caused by dehydration, and to retard the growth of micro-organisms. Frankfurters, for example, get yeasty and develop an acetic acid (vinegar) odor if they are not protected in some way. The only adjuvants which are permitted for use in meat are sugar, spices, and similar seasonings. Use of bacteriostats is prohibited, apparently because--if the meat is afforded such protection against spoilage--carelessness with regard to sanitation and cleanliness would become easier to tolerate than is desired.

Fresh-dressed chickens and turkeys are packed in ice, without any spray or dip coating being applied, and then are shipped under refrigeration to the distributor. Frozen chickens and turkeys are wrapped in plastic films and shipped in bulk. The principal requirement is that the coating be moisture-proof; oxygen permeability is not important.

Propylene glycol, sprayed on the surface of innerliner polyethylene bags, sometimes is used to enhance the appearance of frozen poultry. No other coatings are used on edible fowl. Poultry, ducks, and geese may be dipped in petroleum wax before being plucked to aid in removal of extremely fine feathers, which otherwise escape the automatic pluckers. This wax is inexpensive (about $0.12 per pound), and the total market amounts to only 125,000 to 150,000 pounds per year.

Fish and shellfish need protection against dehydration. Fresh fish, bulk frozen fish, and shrimp generally are shipped and stored inside a frozen water glaze coating. Bulk fish in 5- to 40-pound blocks, from which fish sticks and fillets are cut, are "shock" frozen about -40°F., then removed and dipped in a brine solution. This solution then freezes on the fish to form what is called a "water glaze." It adds about 5 percent by weight to the fish at a negligible cost.

Individually packaged fish products are usually wrapped in waxed paper or polyethylene filmwraps. Halibut and salmon blocks may be preserved in the frozen state for almost a year, with one or two reglazings sometimes required. Polyethylene-packaged fillets often are held for as long as 2 years. Shellfish, being much smaller individually than fish blocks, are not subjected to the water glaze but are stored for shorter time periods in crushed ice. This protection is inexpensive but not entirely satisfactory.

Cheese.--Most natural cheese, before being aged for shipping, is coated with paraffin or microcrystalline wax and, to an increasing extent, with polyethylene or related polymers as well. When cheese is sent from the cheesemaker to the cheese processor, usually in 40-pound blocks, a protective coating is desirable to reduce mold growth and dehydration, as well as to protect against dirt.

The covering must be tight, and the choice between materials depends upon (1) the desired degree of protection, (2) the channels of distribution to be used, (3) the desired shelf life, and (4) the cost. Although wax coatings are not truly edible, they are nontoxic and are usually removed by the consumer before the cheese is eaten. The price of cheese waxes is about 20 cents per pound.

Eggs.--Eggs which are being stored for a month or longer are coated with mineral oil or mixtures of paraffin wax and mineral oil, or mixtures of a silicone and mineral oil. The oils are cheap, inert, and are easy to apply. They have adequate wetting action. The purpose of the oil is to seal the shell pores to reduce carbon dioxide and moisture loss from the egg. As the industry moves toward more rapid movement of eggs to consumer, less seasonal production, and less storage, there is a decrease in the use of coatings. Mineral-oil-based egg coatings cost approximately 10 cents per pound.

Fruits and vegetables.--The use of added protective coatings on fruits and vegetables is limited to citrus and dried fruits such as prunes and raisins. Citrus fruits are coated with a petroleum wax to reduce dehydration and surface abrasion; dried fruits are coated with various oils to reduce both the loss and the gain of moisture and to resist clumping and sticking. Raisin dehydration is a problem particularly when raisins are used in dry breakfast cereals; the cereal acts as a desiccant. Coatings frequently applied to dried fruits include raisin or grapeseed oil, cottonseed oil, coconut oil, and the acetoglycerides, which are difficult to apply. These fruit coatings are applied at a rate of about 0.5 percent of the dried fruit, by weight.

Fresh fruits and vegetables, such as cantaloups, potatoes, and tomatoes are sometimes given a protective coating, but the use of coatings on these products is infrequent and the requirements for coatings generally are limited to those that give artificial coloring, or are fungicides, or fungistats. At the present time, no added coatings are used or believed to be particularly needed on apples, cherries, or pears.

Nuts.--Fats are used with nuts to serve as a frying or roasting medium and as a protective coating. Many nuts, such as cashews and filberts, must be roasted to be edible, while others, such as walnuts and pecans, are edible raw. On all nuts, there is a need for an added coating to reduce tendencies toward rancidity, sogginess, darkening, and insect infestation. In addition, nuts sold to consumers frequently need to be made more glossy.

In baking applications, the tannin which is present in nuts often causes a brownish discoloration of the area surrounding the nut. Nuts also create problems for the ice cream maker, because nuts can absorb moisture from the ice cream in excess of 4.5 percent by weight, the maximum moisture tolerance level. Above this amount, nuts become soggy.

Vegetable oils are used as both the roasting medium and the protective coating for nuts, the coating normally being picked up during the roasting process. The most frequently used oils are peanut oil and cottonseed oil; minor use is made of soybean and coconut oil. Manufacturers of acetoglycerides have suggested use of their type of film-forming fat derivative.

Food container coatings.--The food container manufacturers try to achieve a glossy finish and, at the same time, reduce the tendency of finished carton surface coatings to fuse or stick together. Products which reduce this tendency of coatings to fuse together are called "anti-blocking agents." The acetoglyceride manufacturers report that this fat derivative can be used in polyethylene or wax-coated surfaces to reduce this blocking effect.

The acetoglyceride fat derivatives are triglycerides containing one long-chain fatty acid group and one or two acetic acid groups per molecule. The product is essentially a derivative of a monoglyceride (emulsifier) which has been further modified by acetylation (addition of acetic acid). The acetoglycerides crystallize to form plastic, nongreasy solids. The crystals of the solidified film are long and ribbon-like and they are interwoven in a felt-like structure in the finished product.

Some of the acetoglyceride films are translucent, and most of them are elastic enough to be stretched severalfold without breaking (34).

The present markets for edible coatings, in which the acetoglyceride might compete, are listed in table 10. The markets for nonedible coatings, such as cellophane and polyethylene, are not shown. It is not anticipated that the acetoglycerides will be able to compete against these products.

Table 10.--The protective coatings market, 1962

End-use commodity	Million pounds
Meat, fish, and shellfish	Negligible
Cheese	2
Eggs	1
Fruits	1
Vegetables	Negligible
Nuts	35
Food containers	Negligible
Total	1/39

1/ Includes 4 million pounds of inedible protective coatings.

Source: IIT Res. Inst.

The markets for cheese wax and egg mineral oil are shown in table 10, also--even though these coatings are not truly edible--because it is anticipated that acetoglycerides may be able to capture all or part of these usages. These data show that the only substantial potential market envisioned at this time for existing uses is for edible nut coatings, and part of this usage is for a roasting oil medium with the coating benefits of secondary importance.

Competitive Factors

The general requirements for an edible coating are (1) that it be nontoxic and preferably nutritious, (2) that it be effective in reducing the rate of dehydration while, in some uses, permitting a free exchange of oxygen and carbon dioxide, (3) that it be resistant to abrasion, (4) that it be transparent, and (5) that it be reasonably inexpensive to purchase and apply.

No edible coatings are used at present on meats. Before the fat-derived acetoglycerides are suitable for such use, they must be demonstrated to have the ability to withstand abrasion without cracking or chipping. This is a requirement for a coating for both aging meat and processed meats. Meat packers have found acetoglycerides deficient in this respect. A second criterion is that the coating be transparent, so as not to give a cloudy or waxy appearance to the meat. Most packers report that acetoglyceride coatings are too opaque to be used on consumer products. Third, meat coatings must not become sticky at normally encountered temperatures. Manufacturers of processed meat reported that softening points for the coating below 120° F. are unacceptable. At the other extreme, processors of frozen fish reported that the acetoglycerides cracked at below-freezing temperatures. During storage, meats must be cooled, regardless of the presence of a coating, to retard the anaerobic growth of micro-organisms.

Consumer reaction to the purchase and use of products with a fat coating has not been determined. Developers of acetoglycerides hope that their fat covering will be allowed to become part of the fat drippings of the meats during cooking. Otherwise, the inconvenience of removing the acetoglyceride coating may be a serious obstacle to use on consumer products. Inedible outer coverings always will be required on meats packaged for the consumer, for brand identification, and to provide the necessary sanitary protection to the surface of the edible product. The potential value in use of an acetoglyceride inner covering that will help reduce the serviceability demands put upon the outer wrap and permit use of less expensive inedible protective films outside is the best hope for gaining a market position for acetoglycerides as meat coatings.

Cheese processors reported that acetoglyceride coatings they had tested tended to crack and permit the growth of undesirable mold; this is also a deficiency of some waxes. When this cracking occurs, recoating is necessary. Some petroleum waxes appear to be fairly satisfactory from a technical standpoint.

In addition, the price of nontoxic cheese wax is around 15 cents per pound, compared to approximately 60 cents per pound for acetoglycerides. For eggs, the use of mineral-oil coatings is technically satisfactory. They also have a decided consumer-sales point appearance advantage over acetoglyceride coatings. 17/ In addition, the per-pound price of mineral oil is only about one-tenth the price of acetoglycerides.

For fruits and vegetables, the scarcity of grape-seed oil, sometimes called "raisin oil," has caused a search for an additional material source for coatings on dried fruits. Acetoglyceride coatings are being tested in these uses but difficulties have arisen in applying the coating satisfactorily. At present, spraying the fruit is preferred over dipping, but in spraying operations the hot acetoglycerides begin to solidify before the fruits are completely covered. Raisin processors reported they are optimistic regarding the possible future use of this fat derivative.

The use of acetoglycerides as a coating on the ends of banana stems to reduce the growth of mold has been reported on an experimental basis. The entire banana cannot be coated, however, for there must be a gaseous exchange as the fruit ripens.

As a nut coating, the acetoglycerides must demonstrate that they are more effective than other less-expensive fats now being used. Competing peanut and cottonseed oils, for example, sell for less than 20 cents per pound, one-third the per-pound price of the acetoglycerides.

17/ Prof. L. E. Dawson, Michigan State University, private correspondence.

In all of these applications, as well as in food container coatings, the acetoglyceride coatings must overcome several technical deficiencies, which have been noted, as well as offer some additional advantage to justify their relatively high cost.

Market Potential

The potential market for edible coatings is largely in terms of a new market, where in many potential uses the only competition is the absence of a coating. The edible coating market and the 1967 outlook are shown in table 11

Table 11.--The market potential for edible protective coatings

End-use commodity	1962	1967 market for improved acetoglycerides
	Million pounds	
Meat, fish, and shellfish	Negligible	27
Cheese	2	2
Eggs	1	1
Fruits	1	4
Vegetables	Negligible	Negligible
Nuts	35	38
Food containers	Negligible	1
Total	39	73

Estimates of the market potential for edible coatings are based upon the assumption that developments in acetoglyceride technology will continue at the present rate and that deficiencies in the product will be largely overcome. Based on the projected rates of consumption of commodities involved and use of the recommended rate of application of acetoglycerides, the following quantities could be used on meat and processed meat products, assuming use on 10 percent of the volume of these meats:

Meat, fish, and shellfish	Million pounds
Beef	5
Veal	3
Pork	7
Ham	1
Bacon	1
Sausage	1
Frankfurters	1
Chickens	2
Frozen fish	2
Shellfish	4

Substantially untapped markets for edible meat coatings exist in potential uses on frozen products for institutions such as hotels, restaurants, and other institutional food service outlets, where the appearance of the uncooked meat is not critical. In

addition, some consumer-packaged products, such as whole chickens, turkeys, hams, and shellfish present excellent opportunities for fat-derived coatings. Estimates developed for cheese and egg coatings are taken from the markets now held by petroleum wax and mineral oil, respectively. Coatings for dried fruits and large-stemmed items such as bananas promise large new market sales opportunities. Some, but not all, of the nut-roasting market will be competitive for acetoglycerides, and expanded use will be found for antiblock agents.

There are some new products which may compete with the acetoglyceride in protective coating applications. These potential competitors include fatty acid esters of fumaric, succinic, and adipic acids, which form fine-grained crystalline structures with hard surfaces at 90° F., and amylose-starch esters, which form a pliable and transparent film of rather low tensile strength. Both type films are now undergoing development, and their impact upon the future of acetoglycerides cannot be determined at this time.

Research and Development Needs

With sufficient improvement in the acetoglyceride coating, a 73-million-pound market appears to be available within 5 years. The specific research and development needs have been mentioned earlier in this section, and they are well known within the industry. These general areas include:

1. Abrasion--more resistance to scuffing, cracking, and peeling;

2. Transparency--sufficient transparency to avoid a cloudy, wax-like appearance which is distasteful to consumers;

3. Cost--reduction of the present 60-cent-per-pound price by at least one-half, to compete with low-cost waxes and mineral oils.

Such advances are necessary before any substantial market can exist for the acetoglyceride protective coating.

THE MARKET FOR FOOD LUBRICANTS

Food lubricants are used extensively in machinery which contacts food (table 12). Traces of the lubricant may be accidentally picked up and retained by the food particles. The food machine lubricants must be edible and nontoxic. It is desirable, though not necessary, that they be nutritious as well.

Table 12.--The food lubricant market, 1962

Use	Mineral oil	Vegetable oil	Total market
	Million pounds		
Divider oil	6	--	6
Pan and trough grease	2	15	17
Slab oil	Negligible	2	2
Total	8	17	25

Present Market

The present lubricant market is shared by mineral oil, vegetable oil, and mineral-vegetable oil mixtures, each of which is described briefly:

Mineral oils.--This lubricant is derived from petroleum, and while edible it has no nutritional value. It is used exclusively as a divider oil in baking bread, because it does not polymerize and retains its lubricating properties for long periods of time.

The Food and Drug Administration has set a maximum limit of 1,500 parts per million on the amount of mineral oil which can be absorbed by bread and rolls. 18/ Some investigations have shown that the mean absorption level of the mineral oil in bakery products is about 900 parts per million (23). In confectionery products, the use of mineral oil has been prohibited altogether. 19/

Vegetable oils.--Edible vegetable oils are used widely as food lubricants. Cottonseed oil and shortening are used as pan and trough greases in baking applications; whereas soybean, cottonseed, and coconut oil are used as a slab oil in the confectionery industry.

The major technical disadvantages of the vegetable oils are tendencies to polymerize and become gummy at elevated temperatures caused by the heat of friction. In addition, the unsaturated fatty acid groups that cause the vegetable oils to be liquid at room temperature also make them susceptible to rancidity.

Mineral-vegetable oil mixtures.--In an effort to combine the desirable features of both mineral oil and vegetable oil--and to reduce some of their drawbacks--mixtures of the two frequently are used as pan and trough greases in baking. The usual ratio of vegetable oil to mineral oil is 1:9. The common usage level of pan and trough grease is about one-half pound per 1,000 pounds of bread.

The 1962 market for food lubricants was estimated to be 25 million pounds.

As shown in table 12, mineral oil is used exclusively as a divider oil, whereas vegetable oil is the dominant lubricant for use as slab and trough greases, and as a slab oil. In the present market, increases in vegetable oil usage as a divider oil must come at the expense of mineral oil consumption.

Competitive Factors

The general requirements for a food lubricant are that it (1) be light in color, (2) be fairly viscous, (3) melt well below room temperature, (4) be bland in flavor and odor, and (5) be highly resistant to rancidity and polymerization. Before examining the relationship of these requirments to specific lubricants, it is necessary to consider the general nature of the lubricant uses (7).

18/ Food and Drug Administration FDC Regulation No. 121,1146, "White Mineral Oil", dated March 12, 1964.

19/ See footnote 15.

Divider oils.--Bread dividers determine the size of bread loaves by physically separating a portion of the desired weight from larger volumes of dough. The dough is measured volumetrically by means of plungers and pockets. The plungers are adjusted to change the pocket space, and, in so doing, determine the volume of the dough the pocket receives. To obtain the correct dough weight, the plunger must operate at close tolerances, and the dough must flow evenly into the pockets. Lubricants are used to prevent the dough from sticking to the plunger-divider.

Pan greases.--Modern production techniques use mechanical devices to dump bread and cake from the baking pans. These pans must be heavily greased to prevent sticking and to avoid damage to the bakery product. Silicone resin coatings are a recent development that are widely used to reduce the penetration of baking fats into the pores of the baking pan. Silicone-treated pans can be used many times before recoating with resin is needed. Experience has shown that silicone pans perform much better when they are greased lightly before each use.

The lubricant must be liquid at room temperature, be of proper viscosity to permit spraying onto the pans, and adhere to the sides of the pans.

Trough greases.--After bread and roll doughs are mixed, they are placed in lightly greased fermentation troughs. Each vessel may contain up to 1,800 pounds of material, holding the dough until it is ready to go to the divider. Lubricants are used to reduce the amount of dough that sticks to troughs.

Slab oils.--Lubricants are used in the manufacture of confectionery in much the same manner as pan greases are used in baking. The sugars present in hard candies, taffy, and caramels have a pan-sticking quality which creates the need for lubricants. Slab oils or panning agents, as they are also called, are especially necessary for some starch-molded candies, to provide a sheen and to mask the small amount of starch picked up by candies during molding.

The only food lubricants, excluding silicones and other resin coatings for containers, available to meet these usage needs are mineral oil and vegetable oil. The prices of these two lubricants are not comparable. In 1962, mineral oil sold for about 7 cents per pound while vegetable oil sold for 18 cents per pound--twice that of mineral oil. The rate of use per unit of product also favors mineral oil, because less mineral oil is needed for technically acceptable results.

The total amount of lubricant which a bakery must use is small, however, compared to the amounts of other materials, such as flour, sugar, and shortening. The lubricant price is not always of great significance to the baker. The factors of price, plus technical considerations, would lead to a much wider utilization of mineral oil, at the expense of vegetable oils, if FDA regulations did not limit the usage of mineral oil.

Market Potential

The overall size of the market for food lubricants is governed by production volume of the bakery and confectionery goods that require lubricants. This derived demand relationship places limits on the market for food lubricants, unless new uses can be found for lubricants in other products, or unless the usage rates for bakery and confectionery making can be raised. Neither of these two possibilities appear likely in the foreseeable future, so the lubricant market can grow only as bakery and confectionery production increases. Historically, these markets have increased

slightly faster than population, which has an average growth rate of 2 percent per year (table 1).

The estimated market potential for all food lubricants based upon normal growth rates for bakery and confectionery goods is estimated at 30 million pounds in 1967 (table 13).

Table 13.--The market potential for food lubricants, 1962, and estimated 1967 market

Use	Total market		Vegetable oil share			
	1962	1967	1962	1967 1/	1967 2/	Net gain 3/
	Million pounds					
Divider oil	6	7	--	--	5	5
Pan and trough grease	17	21	15	18	20	2
Slab oil	2	2	2	2	2	--
Total	25	30	17	20	27	7

1/ Estimated on the basis of normal growth.
2/ Estimated on the basis of rapid growth through improved products and also changes in FDA regulatory policy.
3/ Estimated market gain from improved lubricants.

Estimates of the share of vegetable oil in the total market were made under two different assumption bases.

First, it was assumed that little or no technical gains would be made to overcome the present disadvantages of vegetable oils. Estimates of this assumption reflect the "normal growth" of the demand for vegetable oil lubricants. If considerable technical achievements were made--overcoming the rancidity and polymerization problems inherent in the use of vegetable oil--and, second, if the FDA, recognizing the availability of nutritious substitutes, drastically reduced the mineral oil tolerance level, then a more rapid growth in the demand for vegetable oil lubricants could be expected.

The "net gain" represents the size of the market increase which improved vegetable oils might attain, over and above the market which would be attained through "normal growth."

Research and Development Needs

The need to improve vegetable oils through reduction of their tendencies toward rancidity and polymerization has been mentioned. Such improvements have a potential reward of a 7-million-pound net increase in this market for vegetable oils.

The use of acetoglycerides is a recent development of the Southern Utilization Research and Development Division of USDA's Agricultural Research Service. The

product appears technologically feasible from user-experience reports, but its 60-cents-per-pound price is roughly three times the cost of unmodified vegetable oil and nine times the cost of mineral oil (6).

Acceptance for wide commercial usage of acetoglycerides depends (1) on finding largely new or unmet needs they can satisfy, and (2) on their being tolerated from a cost standpoint. Much of other recent progress toward expanded vegetable oil lubricant usage (primarily cottonseed oil and butyric acid) also has stemmed from development research of the Southern Utilization Research and Development Division. 20/

20/ Feuge, R. O., Progress on the Utilization of Confectionery Fats, a paper presented before the National Confectioners Association 77th Annual Convention, Philadelphia, Pa., June 5-9, 1960.

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